

Contribution to 1st High Lift Prediction Workshop

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Grid Generation

Overview

- ANSA (geometry handling, surface and volume meshing)
- Unstructured grids with mixed elements – Prisms, Pyramid, and Tetrahedral elements
- Grids prepared for Cell Centered Solver
- Configurations studied
 - Config1 (Slat 30 Flap 25) – Coarse, Medium, and Fine grid level
 - Config8 (Slat 30 Flap 20) – Medium grid level
 - Grids were not generated for brackets

Grid Generation

Grid Specifications

- 100 million cell limit for the grids.
- Number of cells along Trailing Edges was modeled according to the guidelines for each grid level
- Finer mesh was generated along slat, wing and flap tips and roots
- Boundary layers with multiple growth rates were generated on all viscous regions
 - Growth rate 1 (GR1) = 1.2, No. of Layers = 22
 - Growth rate 2 (GR2) = 1.0, No. of Layers = 22
 - Growth rate 3 (GR3), grown to aspect ratio of 0.8, No. of Layers = 11
- Tetrahedral elements were generated on top of the GR3 layers with a growth rate of 1.2

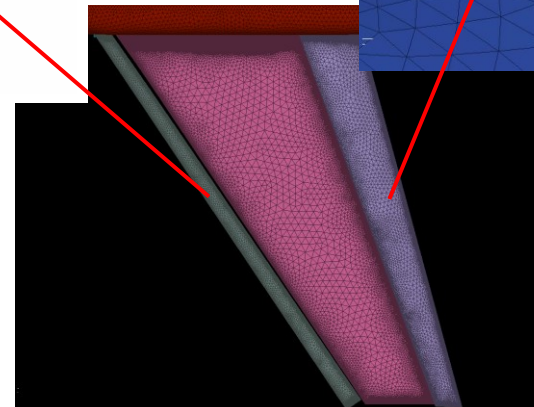
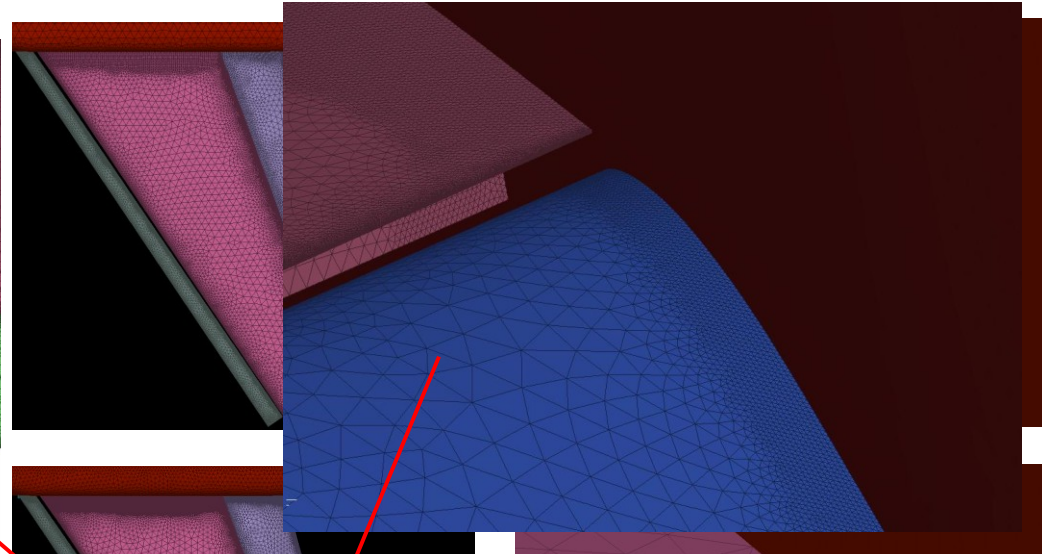
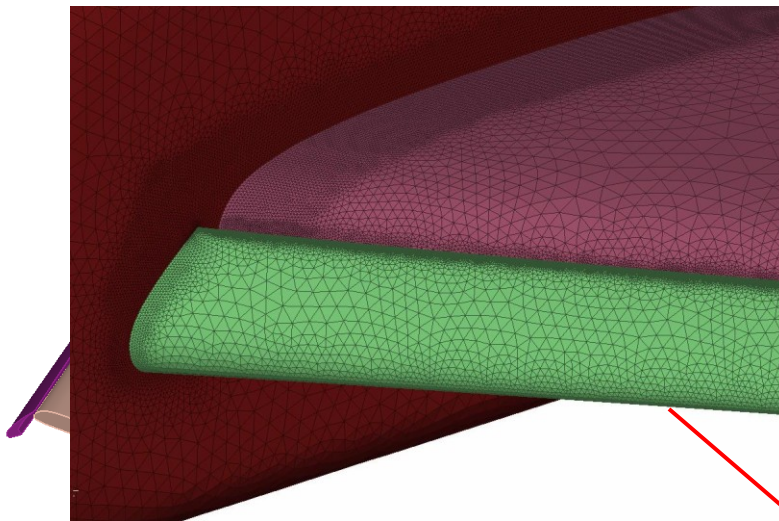
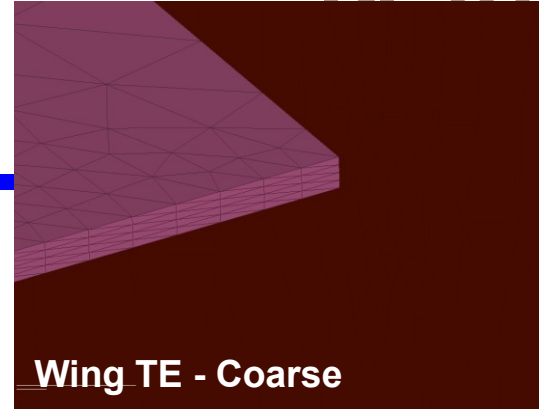
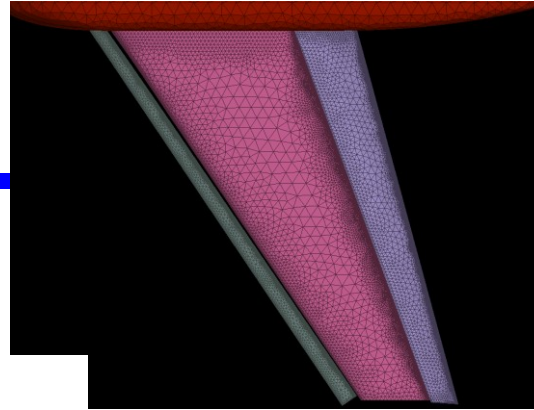
Grid Generation

Grid Statistics

	Config1			Config8
	Coarse	Medium	Fine	Medium
No. of cells along TE	4	6	9	6
Field Nodes (Million)	5.8	14.5	35.1	14.5
Field Cells (Million)	13.7	32.7	78	32.7
Increment in Cells	1	2.4	2.4	2.4
BL Cells	10.6	26.9	65.6	26.9
Percentage of Prisms in Field Cells	74.9%	81.6%	83.8%	81.6%

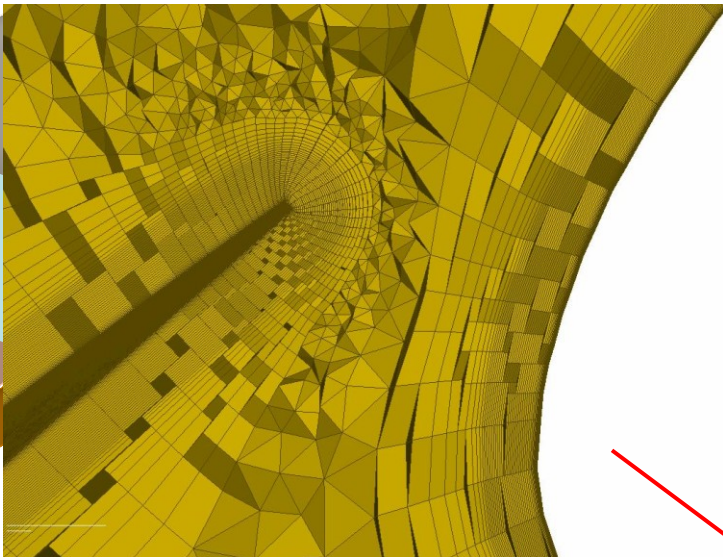
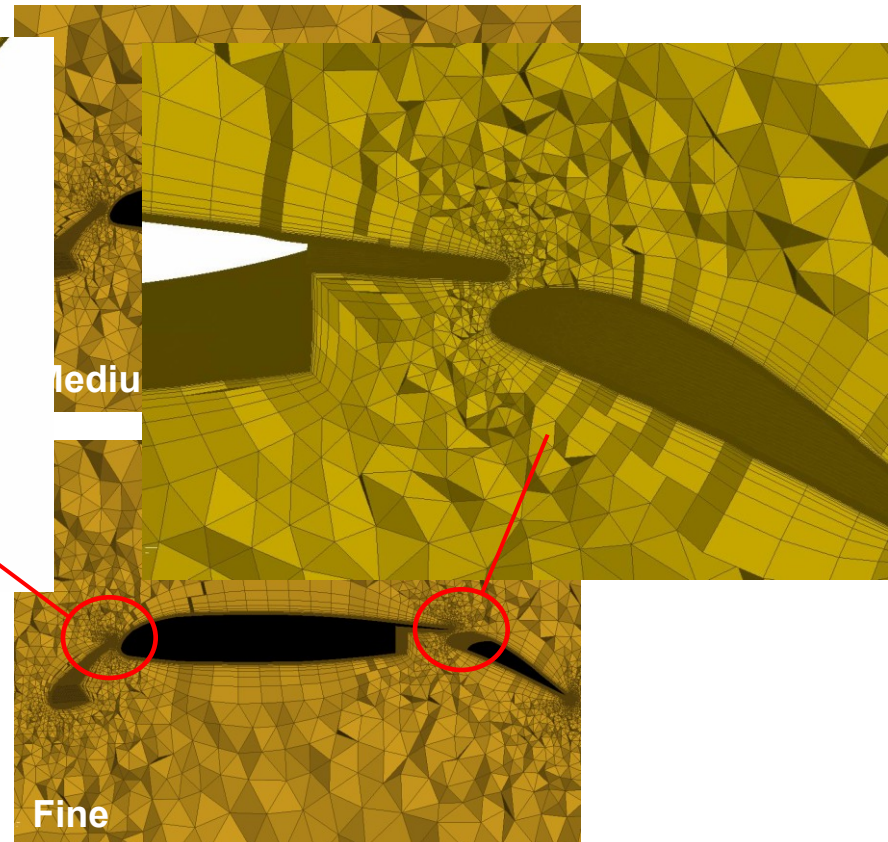
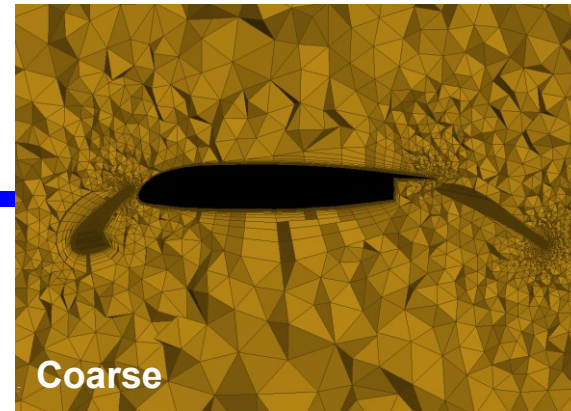
Grid Generation

Surface Mesh



Grid Generation

Volume Mesh



Solver Setup

- Cooperative study by Swift Engineering and BETA CAE Systems
- Solver used, CFD++
- Used a Realizable k-epsilon turbulence model
- Flow Conditions:
 - Mach = 0.2
 - Reynolds Number $4.3e6$ based on MAC
 - MAC of 39.634 in
 - Reference Temp of 520 R
- Cases Studied:
 - Case 1: Grid Convergence
 - Angles-of-attack at 13 degrees and 28 degrees
 - Case 2: Flap Deflection Prediction Study
 - Flap Deflection of 25 degrees and 20 degrees

Case 1: Grid Convergence Study

Alpha = 13 degrees

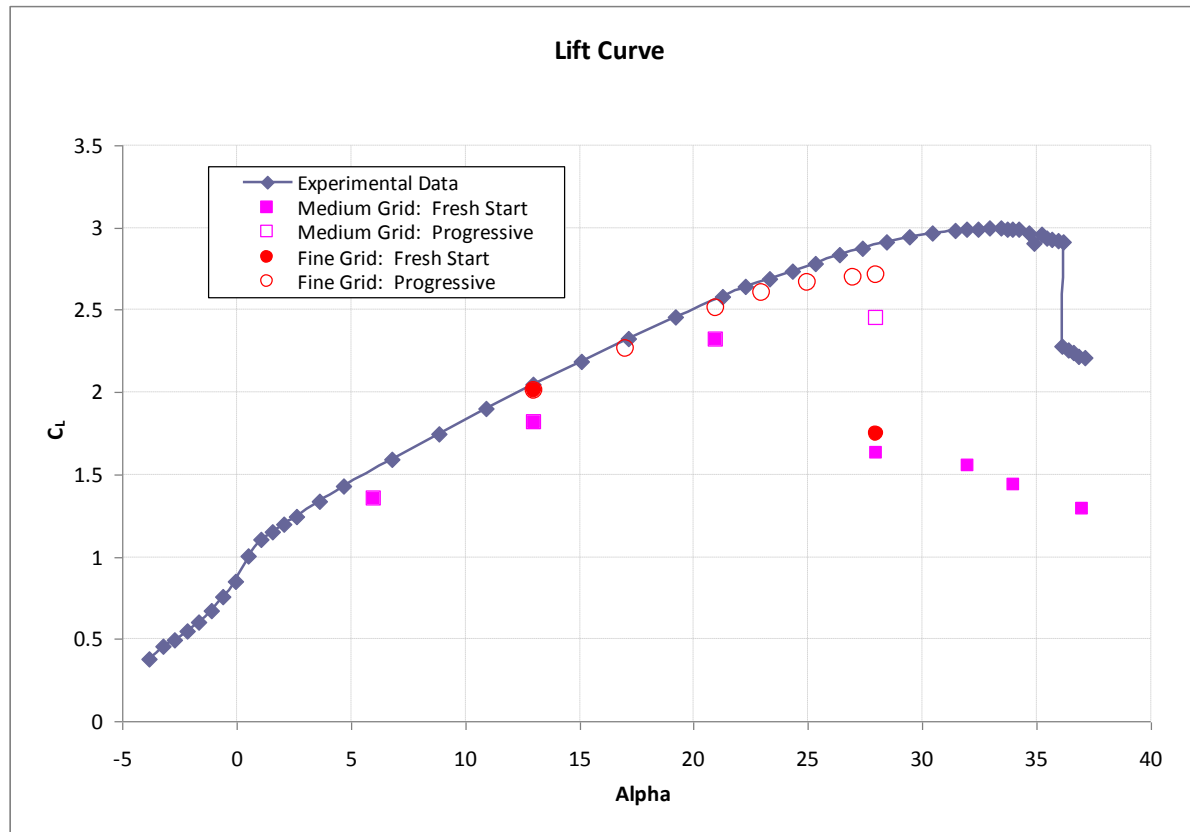
	Cell Count	CL	CD	CM
Coarse	13,738,741	1.6944	0.2739	-0.3558
Medium	32,754,639	1.8132	0.2893	-0.3837
Fine	78,006,183	2.0082	0.3266	-0.4754

Case 1: Grid Convergence Study

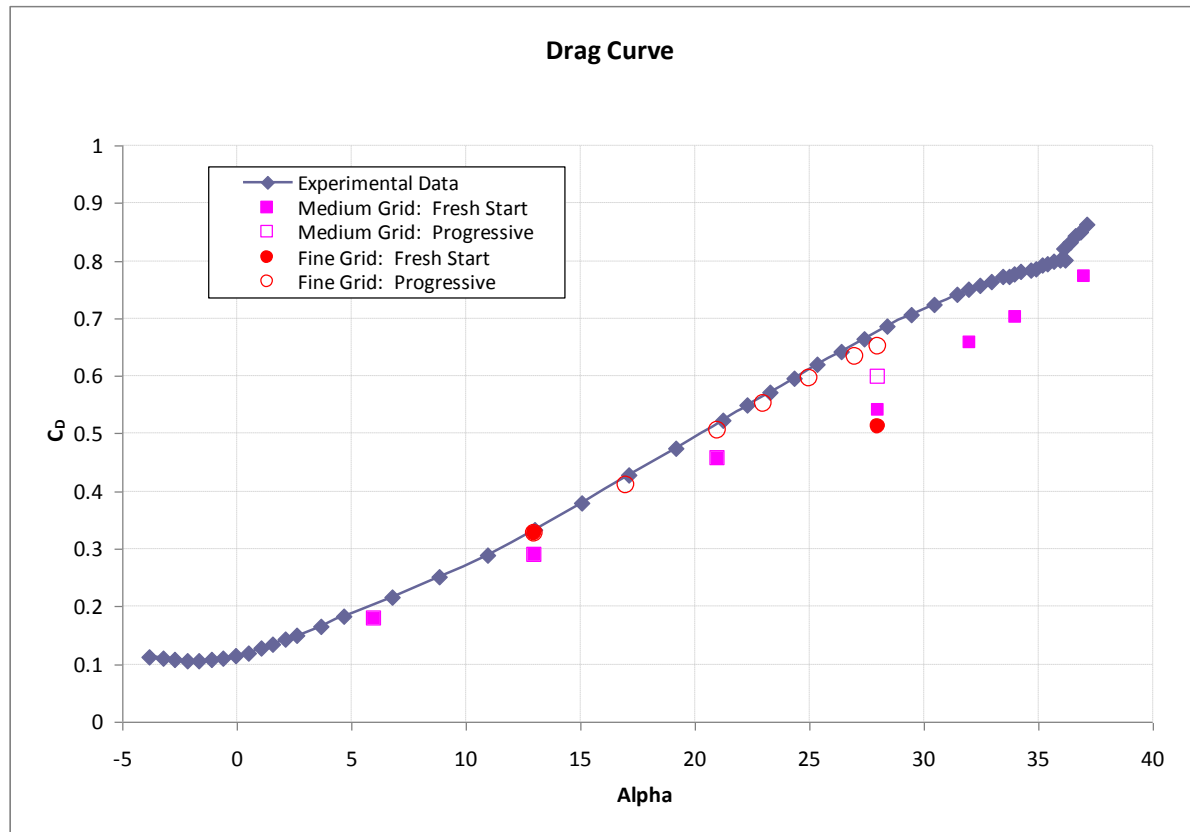
Alpha = 28 degrees

	Cell Count	CL	CD	CM
Coarse	13,738,741	1.8195	0.5681	-0.2254
Medium	32,754,639	2.4487	0.5979	-0.2708
Fine	78,006,183	2.7087	0.6504	-0.3542

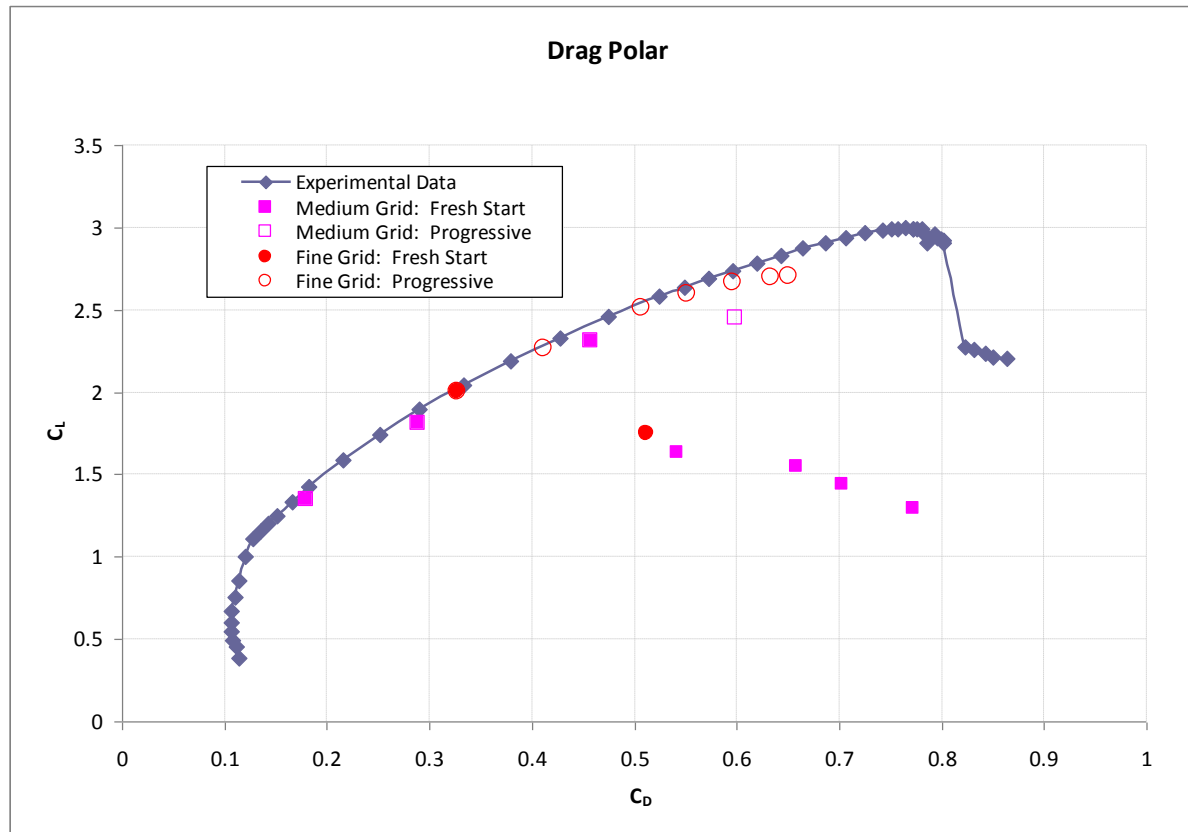
Case 1: Grid Convergence Study



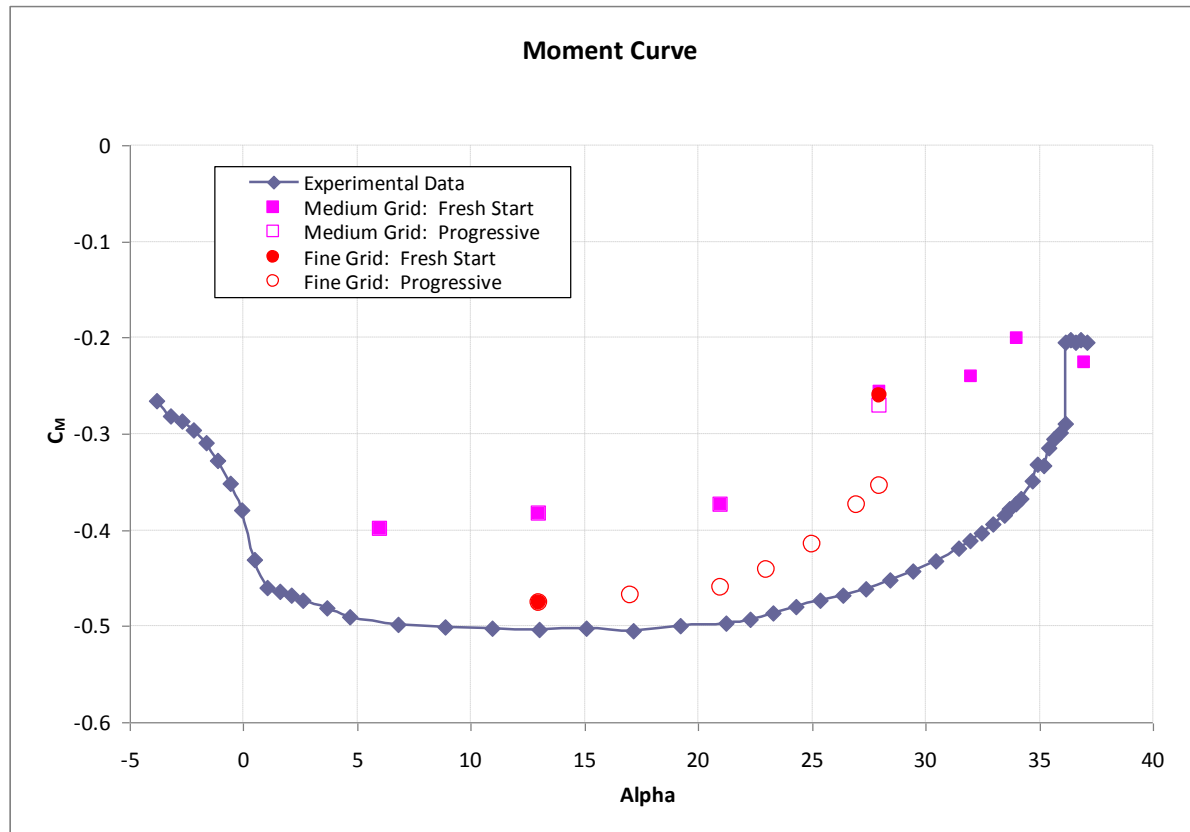
Case 1: Grid Convergence Study



Case 1: Grid Convergence Study



Case 1: Grid Convergence Study



Case 2: Flap Deflection Prediction Study

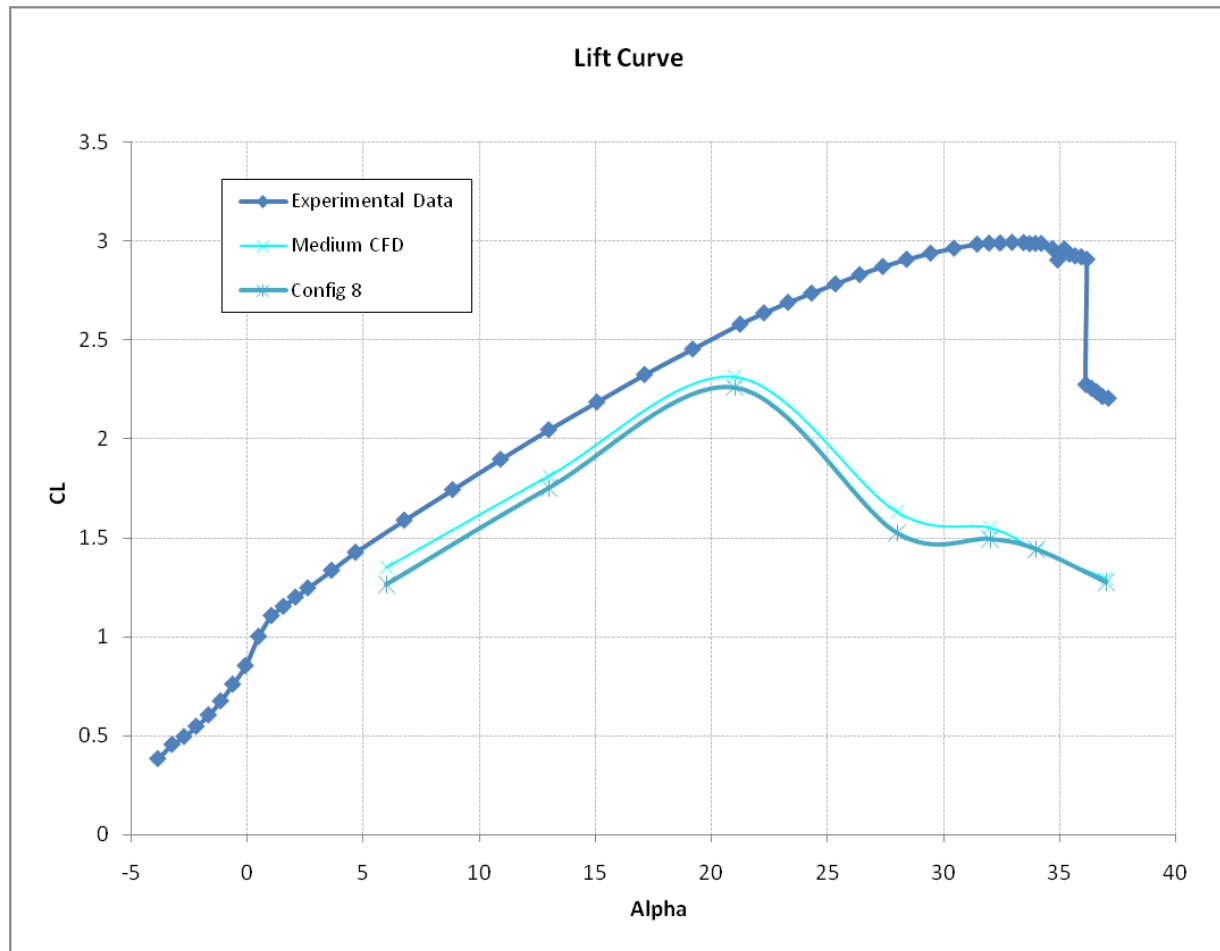
Configuration 1: Flap 25 degrees

Alpha	CL	CD	CM
6	1.3499	0.1795	-0.3993
13	1.8132	0.2893	-0.3837
21	2.3165	0.4572	-0.3743
28	2.4487	0.5979	-0.2708
32	1.5512	0.6582	-0.2402
34	1.4405	0.7020	-0.2012
37	1.2924	0.7723	-0.2262

Configuration 1: Flap 20 degrees

Alpha	CL	CD	CM
6	1.2639	0.1564	-0.3846
13	1.7535	0.2657	-0.3803
21	2.2623	0.4300	-0.3703
28	1.5259	0.4932	-0.2490
32	1.4953	0.5624	-0.2672
34	1.4434	0.6762	-0.1938
37	1.2768	0.7418	-0.2207

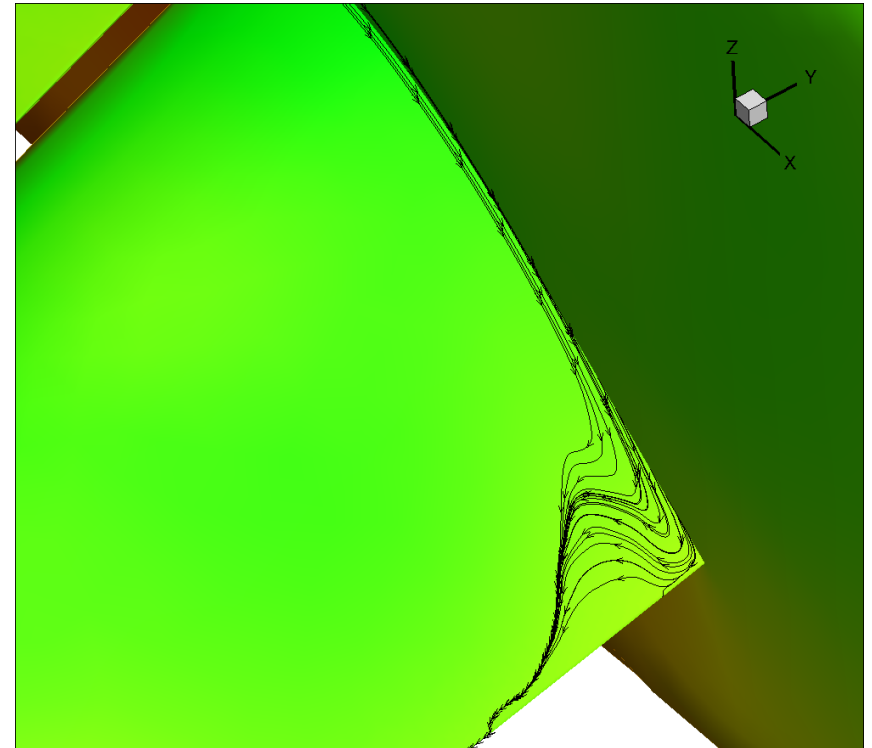
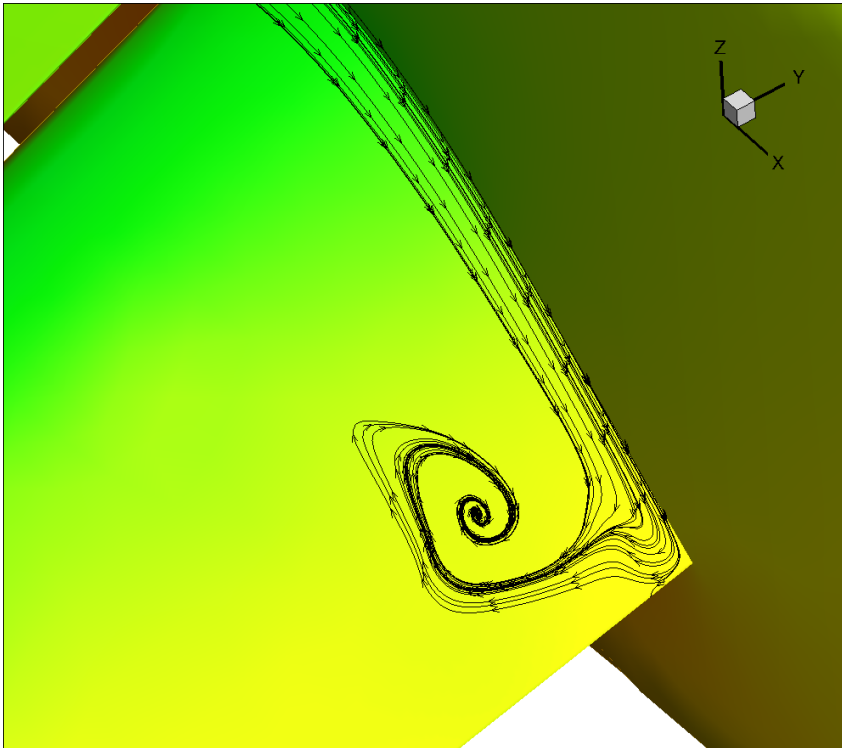
Case 2: Flap Deflection Prediction Study



Flap Separation: Coarse

13 degrees

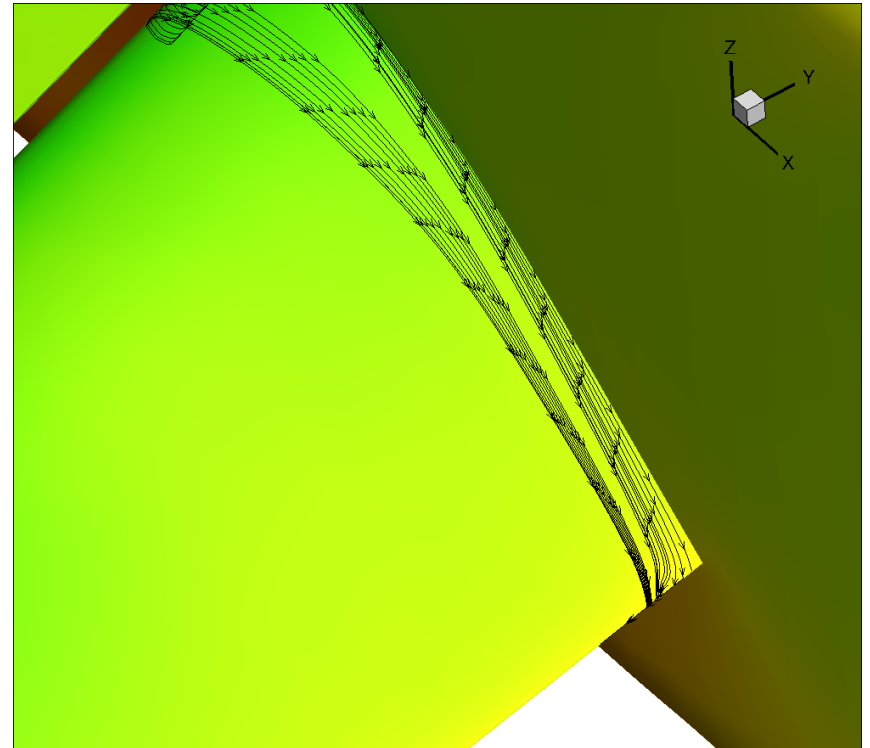
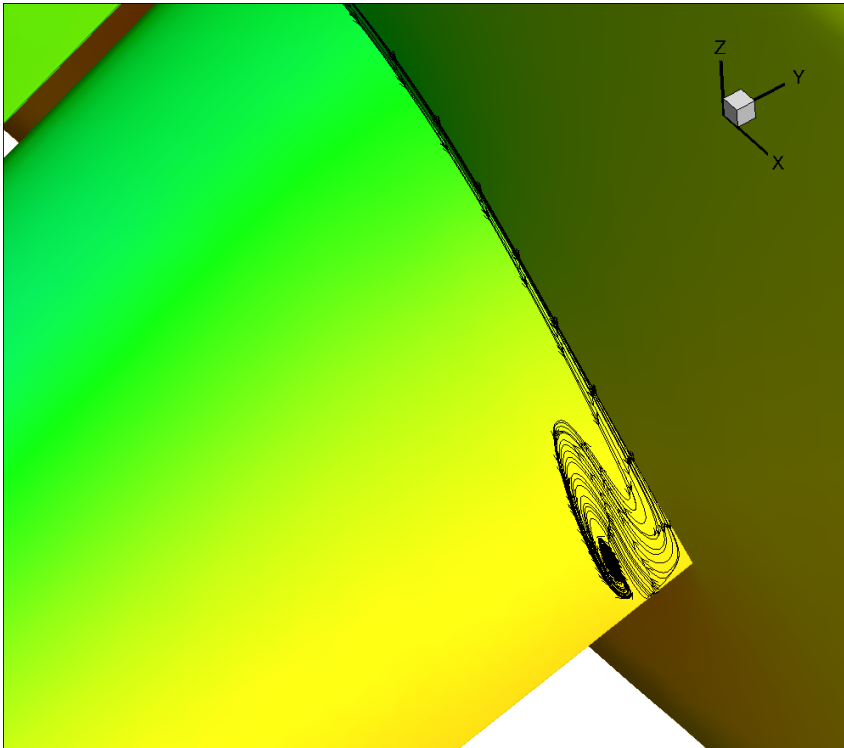
28 degrees



Flap Separation: Medium

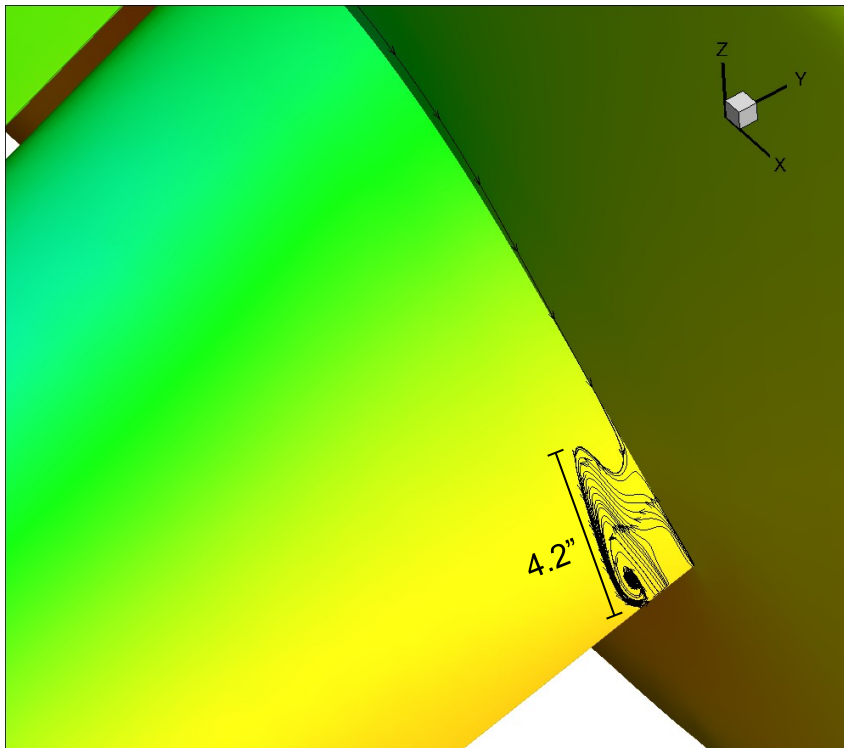
13 degrees

28 degrees

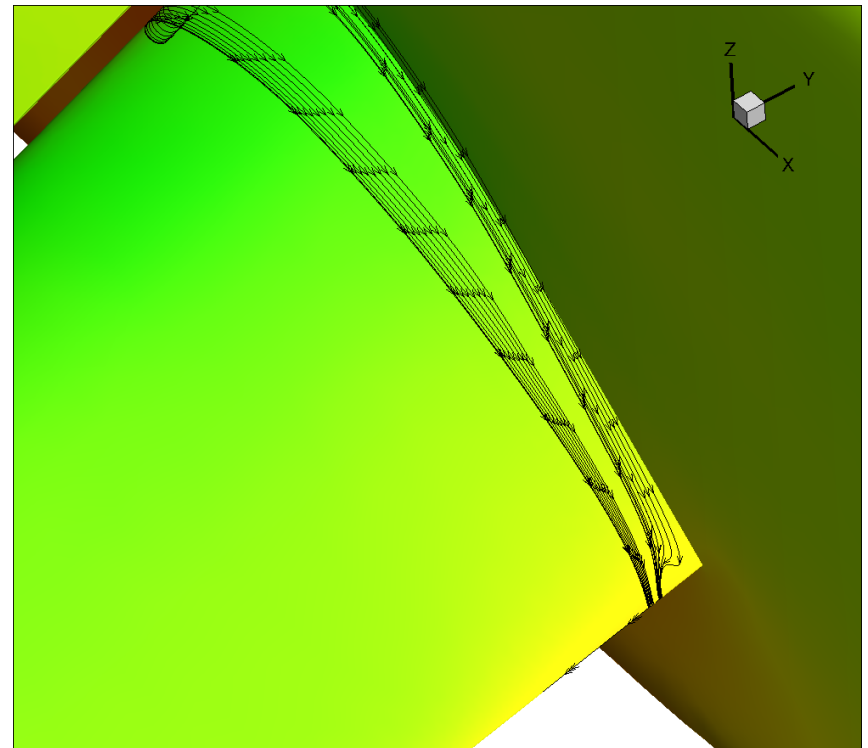


Flap Separation: Fine

13 degrees



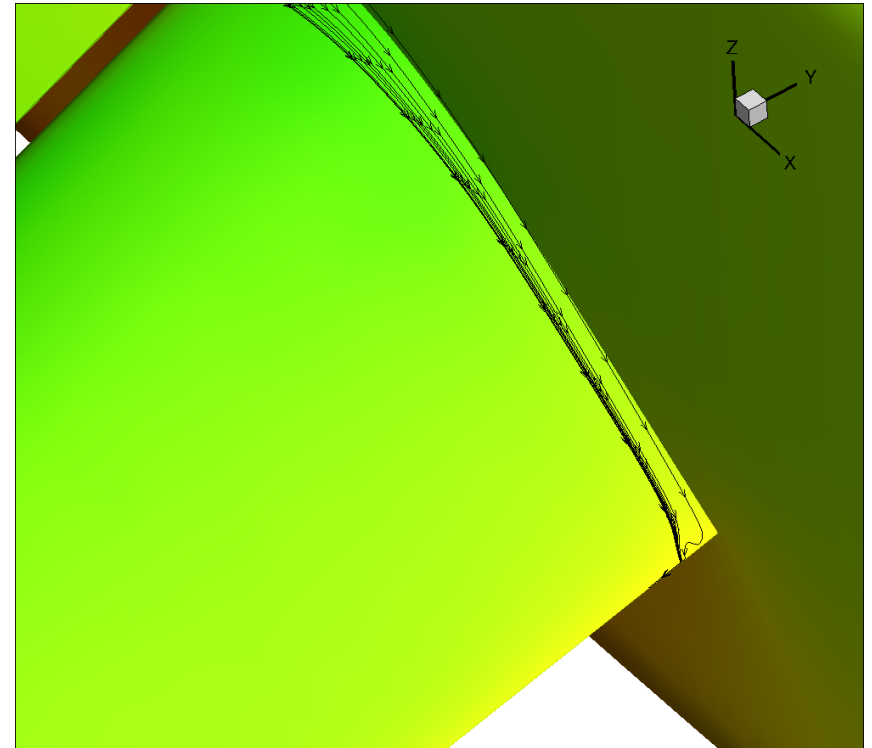
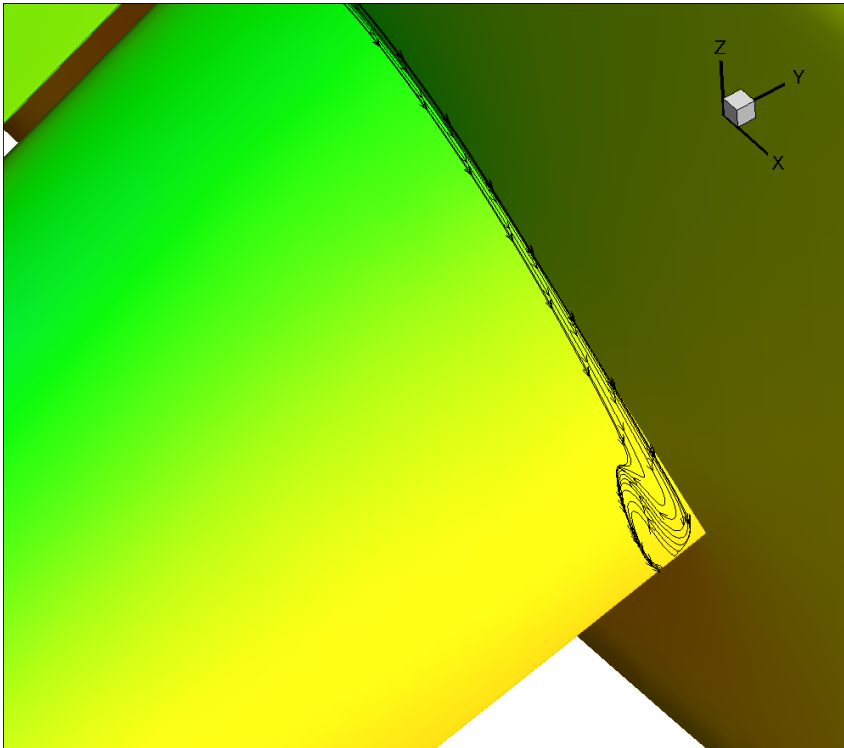
28 degrees



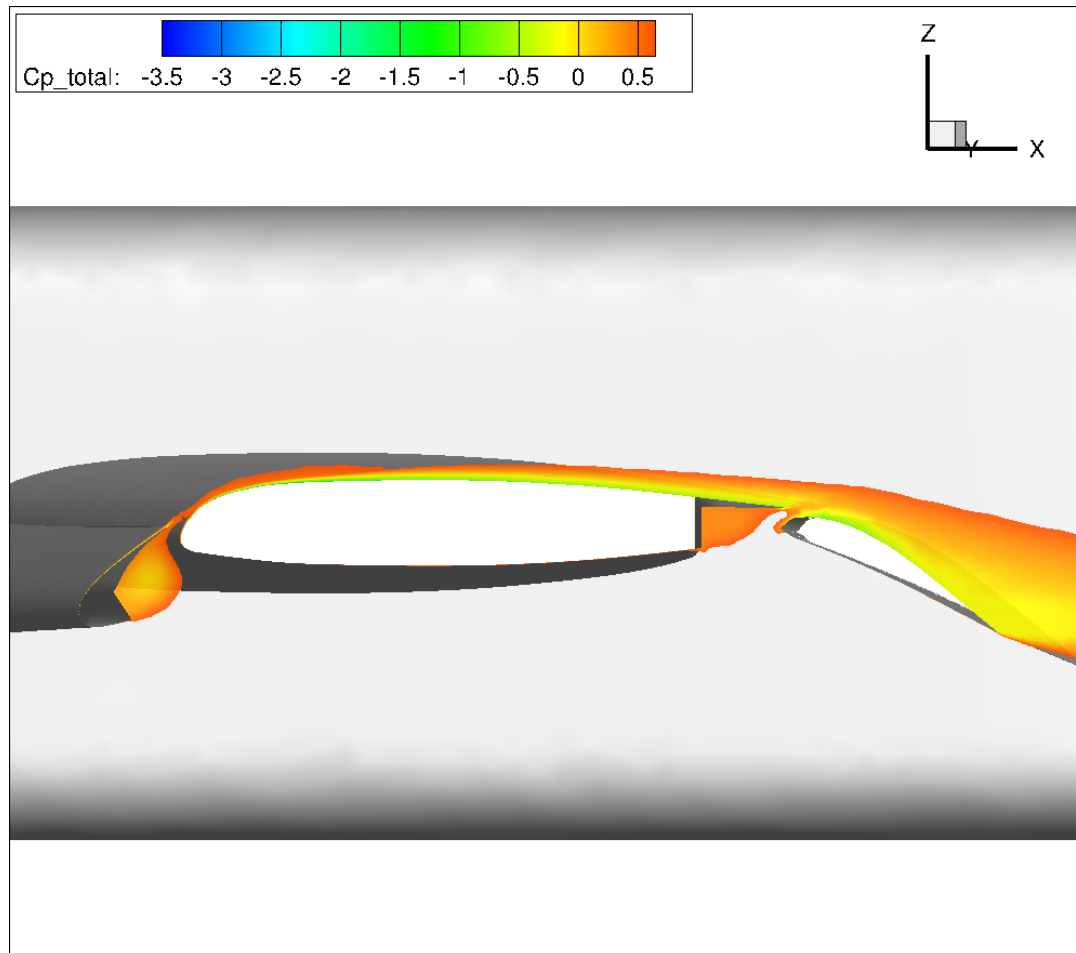
Flap Separation: Case 2 Medium

13 degrees

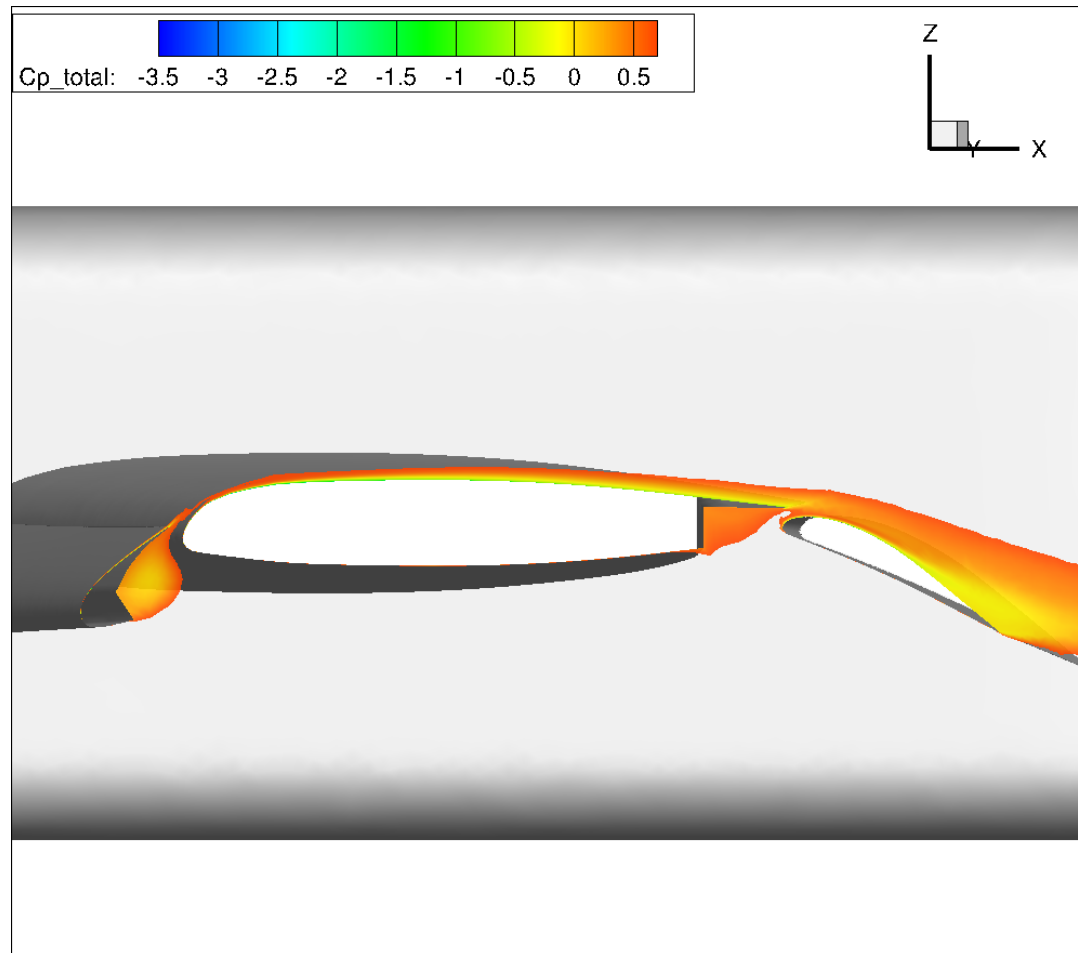
28 degrees



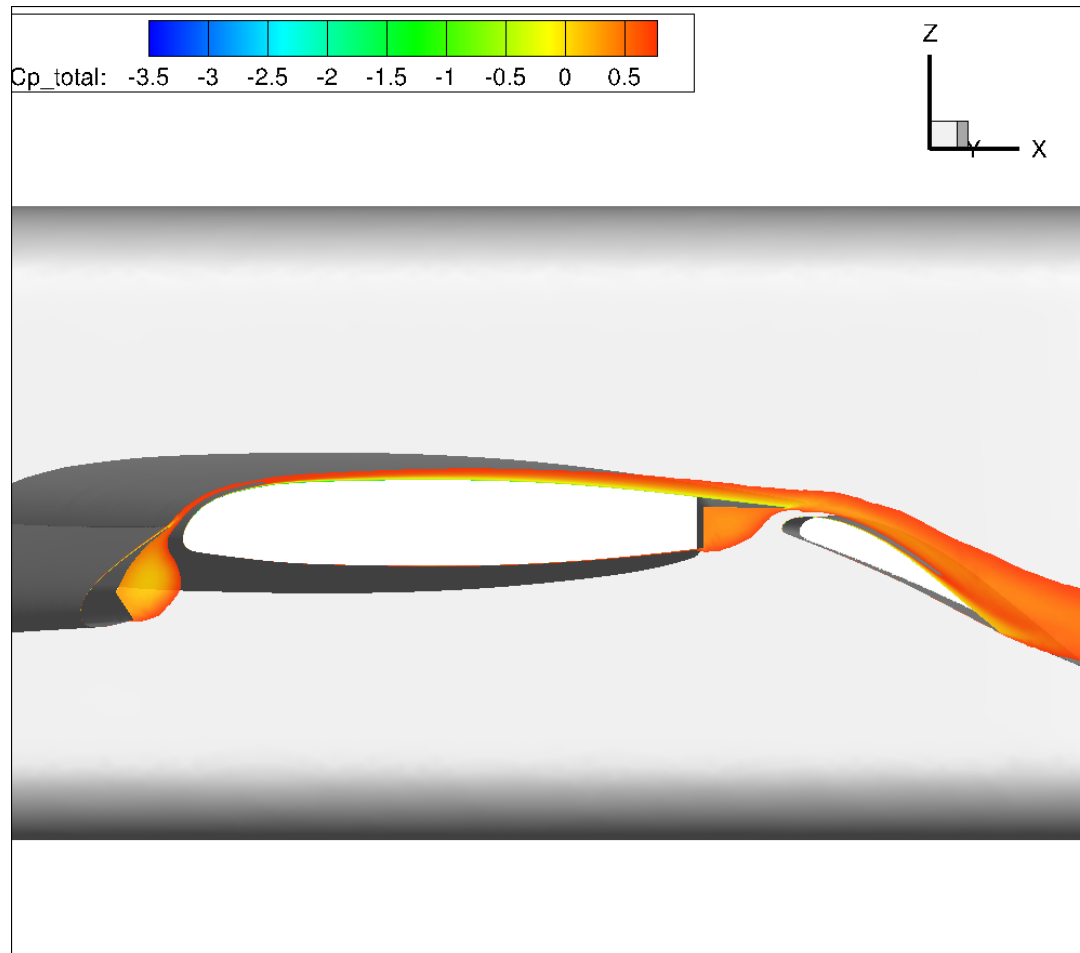
Flow Confluence: Coarse



Flow Confluence: Medium



Flow Confluence: Fine



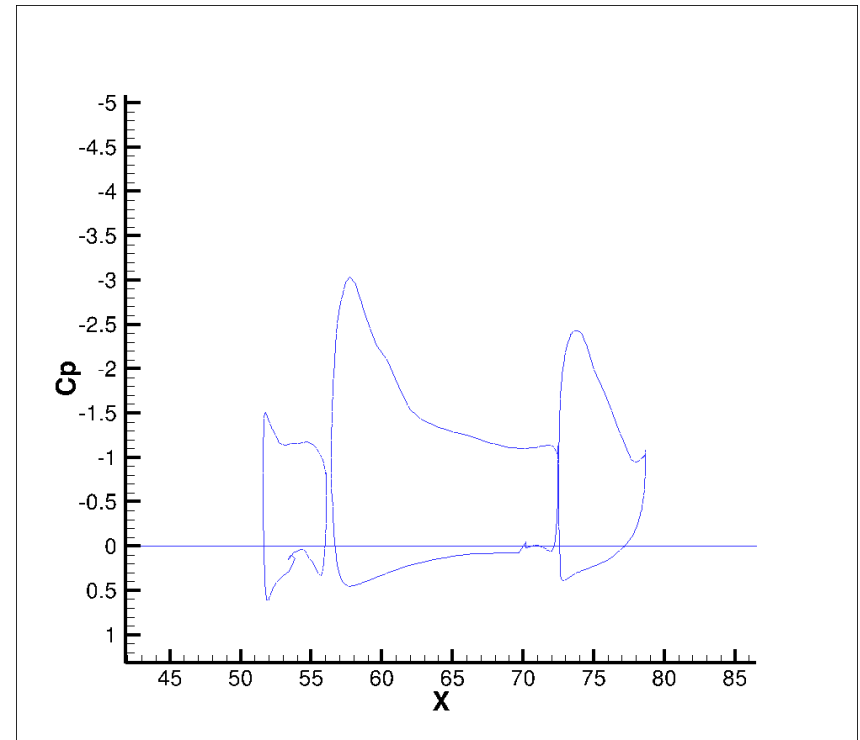
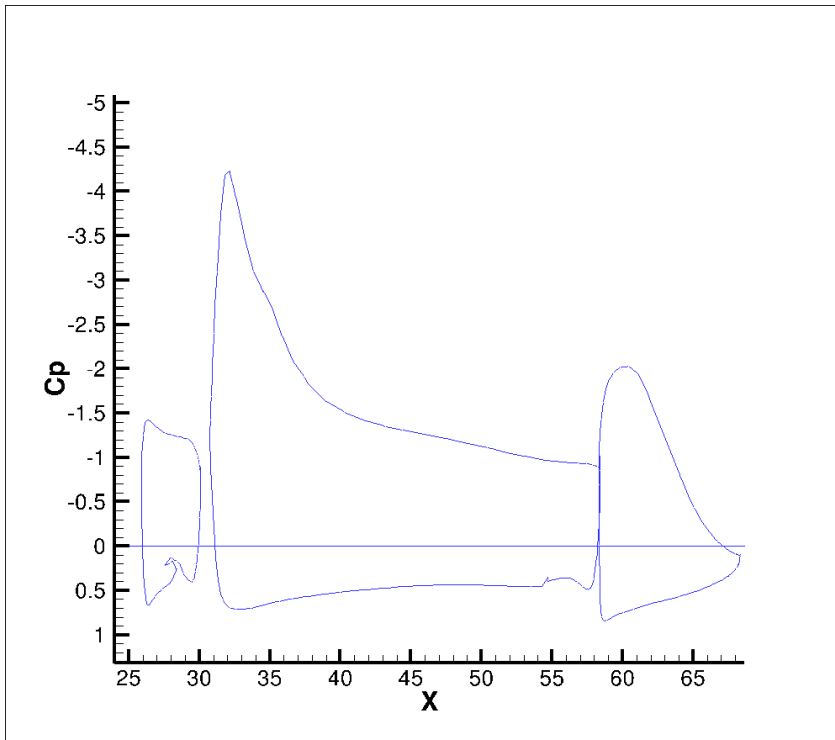
Flow Confluence: Case 2 Medium



Pressure Contours

50% Span

95% Span



Summary

- Cooperative effort between Swift Engineering and BETA CAE Systems
- 100 Million cell limit is a very tight constraint for High Lift Prediction
- Hysteresis was demonstrated in the computations
- Medium Grid level begins to capture flow phenomenon
 - Flap Side of Body separation
 - Confluent Boundary Layers
- Need a “Fine” grid minimum to properly predict coefficients
- Was not able to accurately predict near CLmax conditions.

Future Studies

- Determine initialization issues
- Reanalyze Both cases in the same manner
- Investigate multiple turbulence models